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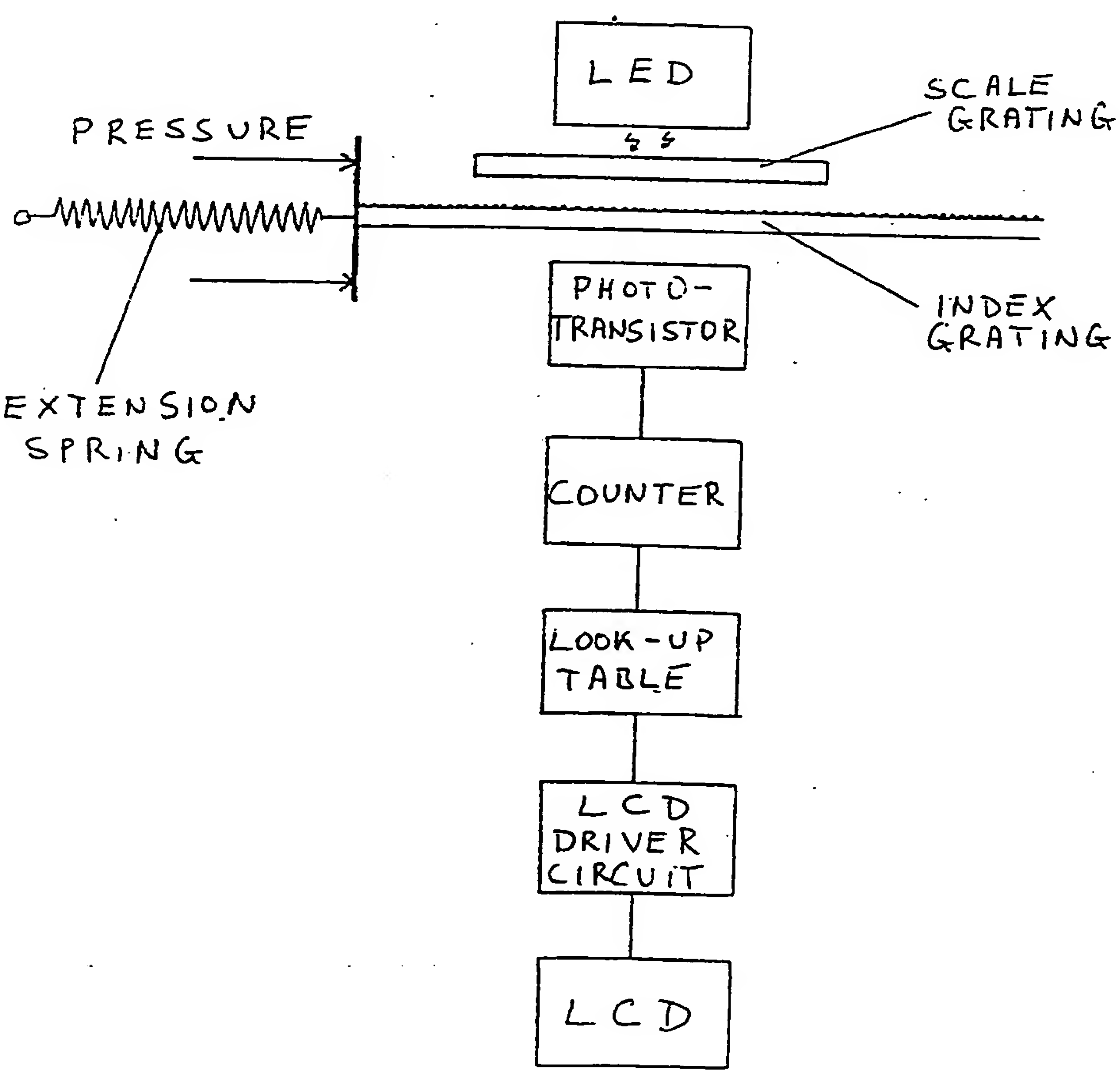
(54) Digital tyre pressure gauge

(57) A tyre pressure gauge converts the pressure into a displacement of an extension spring. The change in length of the spring is measured by means of a moving optical grating fixed to the spring, a fixed optical grating and a LED and photo transistor. Movement pulses are counted and the count entered into a look-up table from which the pressure value is obtained and displayed.

FIG 1



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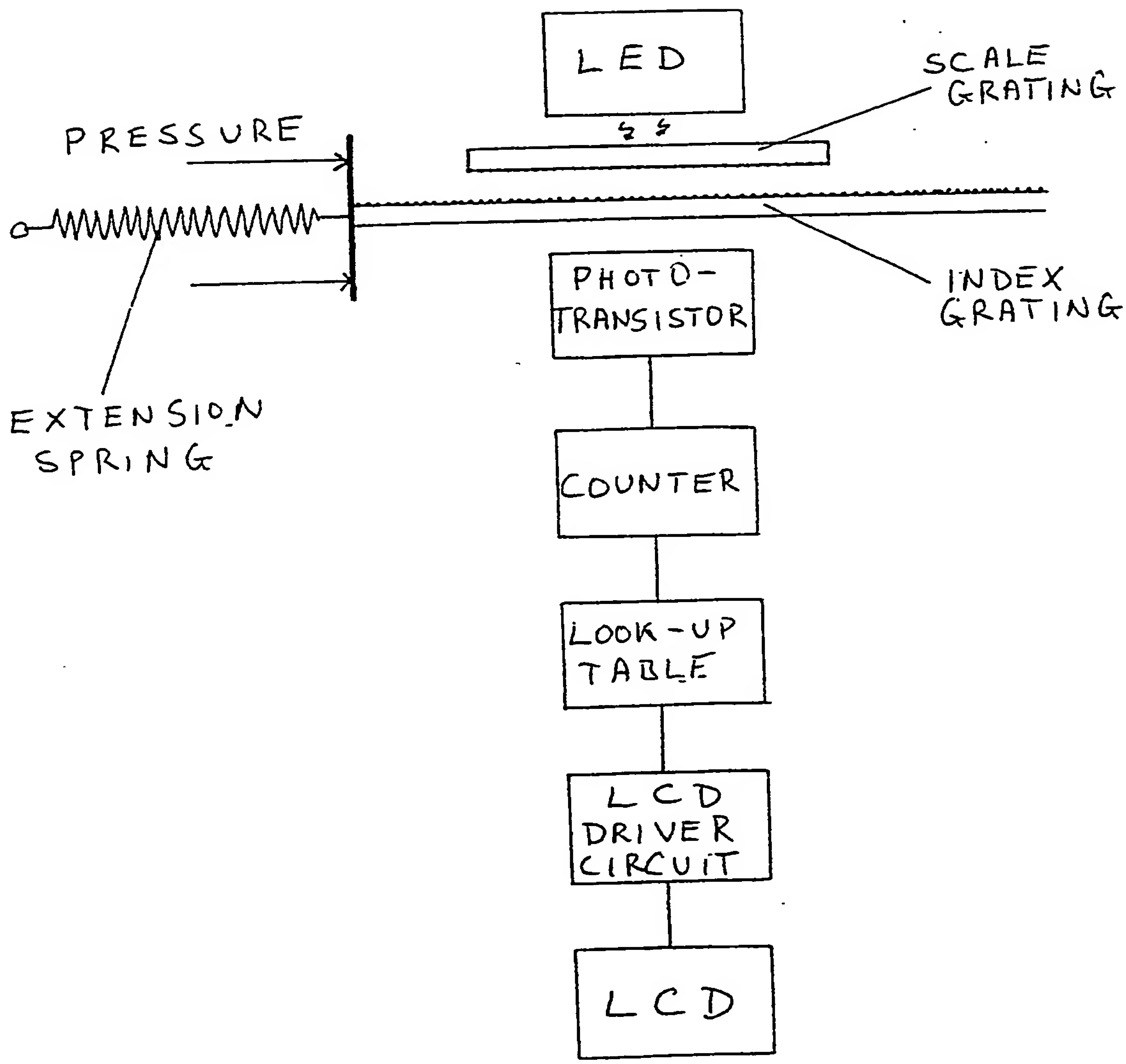
LED
SCALE GRATING
PRESSURE
PHOTO-TRANSISTOR
INDEX GRATING
EXTENSION SPRING
COUNTER
LOOK-UP TABLE
LCD DRIVER CIRCUIT
LCD

FIG 1

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DIGITAL TYRE PRESSURE GAUGE

This invention concerns the measurement of tyre pressure by means of an optical grating sensing the displacement of a spring which changes its length in response to the applied pressure from the tyre.

Conventional tyre pressure gauges are very inaccurate. Typical accuracy of such gauges is + or - 10%. The design to be described is aimed at producing a higher accuracy, but low cost digital tyre pressure gauge.

The pressure is measured by converting the applied pressure into a displacement using an extension spring. The displacement is measured by using two optical gratings. The optical gratings are two glass plates covered with equally spaced thin opaque lines going transverse to the direction of displacement. The block diagram of the digital tyre pressure gauge is shown in Fig 1. The air from the tyre is led into a cylinder and pushes out a piston which is held back by the extension spring.

One of the gratings is fixed to the piston (the index grating). As this grating slides over the other grating (the scale grating), a phototransistor on one side of the two gratings detects pulses of light from a light emitting diode (LED) placed on the other side. The index grating is made to have a displacement of 20 mm at 50 p.s.i. The line width and line spacing are typically 80 micrometres which in this case gives a gauge resolution of 0.15 p.s.i. (Line width and line spacing need not be equal. For example it may be an advantage for the opaque lines to be say 55 microns wide and the transparent lines 45 microns wide.)

The pulses are then counted by a digital counter. For simplicity the counter is made to count the pulses generated as the index grating moves both up and down when the gauge is applied to the tyre and then removed. The number of pulses generated is related to the tyre pressure using a look-up table.

The look-up table consists of two read only memories (ROM) which convert the eight bit word out of the counter into three binary coded decimal (BCD) words. The BCD words represent three binary numbers which when displayed on the liquid crystal display (LCD) shows the pressure of the tyre. The LCD driver circuit consists of three BCD to 7-segment decoders and a square wave oscillator to drive the backplane of the LED.

The tyre pressure can be displayed in both bars and psi, controlled by a switch which essentially changes the input addresses of the ROMs. The LCD displays a 'p' when the pressure is given in psi and a 'b' when given in bars.

The pressure gauge consumes very little power so that a battery

power supply can be used. The pressure gauge is provided with an on/off switch and button to reset the counter before each measurement.

This method of measuring the tyre pressure was chosen for several reasons. The output of the displacement transducer (which consists of the two gratings, the LED and the phototransister) is a digital signal. This an important advantage of this method since no analogue to digital converter is needed to display the pressure on the LCD. This optimises both the simplicity and accuracy of the electronic system required. The pressure transducer has a very low temperature coefficient and is highly linear.

In order to keep the digital tyre pressure gauge very accurate, each gauge can be calibrated individually. This is because each gauge is provided with a spring with different spring characteristics. Also the friction in the cylinder will vary for each gauge. The calibration is done by programming the ROMs. The data to be programmed into the ROMs are obtained by comparing the number of pulses generated with the applied pressure. The relationship between the applied pressure and the number of pulses generated is linear. The calibration can therefore easily be done in mass production using a computerised calibration system where only a few pressures are applied to each gauge. An alternative approach may be possible in which the springs are obtained within close limits and friction variations kept small. Then it may be possible to use a fixed read only memory (ROM) and effect the calibration accurately at a selected point in the scale by pre-setting a fixed number in the counter. In this way the reading could be made quite accurate at say 26 psi and any variations of the spring tension would only affect the slope of the count versus pressure about the selected point. Such an arrangement could dramatically reduce the cost if an application specific integrated circuit (ASIC) could be designed.

The accuracy and reproducibility of the digital tyre pressure gauge depends on a precise count of the number of pulses generated by the movement of the index grating over the scale grating. The circuit is designed with two trigger levels (hysteresis) as shown in Fig 2 such that the gratings must move beyond the second trigger level before the next pulse is counted. This minimises spurious counts, particularly at zero and full scale displacement. In this way the number of error pulses is kept to a maximum of 2 per reading giving the pressure gauge a repeatability of + or - 0.2 psi.

The accuracy of the calibration can be kept within 0.3% by using a high quality reference gauge and a stable pressure source. The effect of the variation in the friction is kept small by keeping the friction as low as possible. Low friction is obtained in the prototype using PTFE as the bearing material. The gratings should be close together, but not so close that they introduce a friction error.

The gauge was designed so that the maximum number of 256 pulses is obtained for a pressure of 50 psi. The lower end of the range was determined by the initial tension of the spring and the friction of the piston. It was set to be 10 psi.

The temperature range of the digital tyre pressure gauge was determined by the temperature response of the components used. Based on these factors, the temperature range is from 0 to 40 degrees Celsius.

Other facilities can be introduced in the design of the digital tyre pressure gauge which would make worthwhile additions to the final device. Such additions may be a low battery indicator and an auto-off switch. If an auto-off switch is used, the 'on' button and 'reset' button which are needed, may be combined onto a single button.

By using the method described, the final cost of the pressure gauge is kept low keeping it competitive with the conventional tyre pressure gauge.

CLAIMS

1. A means of measuring tyre pressure using a grating to determine the change in length of a spring.

2. The use of an fixed grating with similar spacing to the moving grating to detect the movement of the spring.

3. Detection of the movement of the grating according to claim 2 by means of a photodiode and photodetector.

4. Means of counting the pulses produced by the photodetector described in claim 3.

5. A detection circuit with hysteresis, typically a circuit commonly called a Schmitt trigger so that the detected signal has to change by a predetermined amount before a second pulse can be counted. Such a circuit minimises spurious counts when the moving grating is stationary near to the threshold detection point.

6. Means for comparing the count accumulated in the counter with a "look up table" so that the pressure associated with the movement may be obtained.

7. Means of displaying digitally the pressure such as a Liquid Crystal Display (LCD).

8. Means for improving the accuracy by setting an initial count into the counter so the the reading at a chosen pressure is more accurate.

9. A pressure measuring arrangement substantially as described with reference to the drawings accompanying either of the provisional specifications.

Amendments to the claims have been filed as follows

1. A means of measuring tyre pressure using a grating to determine the change in length of a spring.

2. The use the grating as claimed in Claim 1 with a fixed grating with the same spacing to detect the change in length of the spring.

3. Detection of the movement of the grating as claimed in Claim 2 by means of a photodiode and photodetector.

4. A detection circuit for the photodetector as claimed in Claim 3 with hysteresis, typically a circuit commonly called a Schmitt trigger so that the detected signal has to change by a predetermined amount before a second pulse can be counted. Such a circuit minimises spurious counts when the moving grating is stationary near to the threshold detection point.

5. Means of counting the pulses produced by the photodetector as claimed in Claim 3 or Claim 4.

6. Means for comparing the count accumulated as claimed in Claim 5 with a "look up table" so that the pressure associated with the movement may be obtained.

7. Means for improving the accuracy by setting an initial count into the counter as claimed in Claim 5 so the the reading at a chosen pressure is more accurate.

8. Means of displaying the pressure as claimed in Claim 6 or Claim 7 such as a liquid crystal display.

9. A pressure measuring arrangement substantially as described with reference to the drawings accompanying either of the provisional specifications.

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